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Production of Aerogel-Silica Based Super Hydrophobic Waterproof Material in Smart Surface Coatings

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In this study, a homogeneous coating was provided to the nanofiber membrane surfaces obtained by dip coating technique, glass and electrospinning technique from aerogel and silica product mixtures, and the materials were provided to be water-proof, super hydrophobic. By integrating these coatings into industrial scale productions, various product ranges with functional use can be obtained.

Keywords: *Aerogel, silica, dip coating, glass, electrospinning, nanofiber membrane, water-repellent surface, coating*

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1. Introduction

These are surface treatments based on classical and modern technologies in order to change the water retention, mechanical and thermal properties of material surfaces or to attract decorative attention. Different physical or chemical coating technologies can be used in order to improve the surface properties that any material surface does not have or has minimally [1-12].

The most preferred situation in surface coatings is water repellent properties. Hydrophobic effect is the ability of nonpolar molecular structures to act as intermolecular complements in similar intramolecular interactions or in aqueous domains. It is the case that it creates a shield feature that prevents the formation and coming of water thanks to the hydrophobic effect [8-16]. Dip coating technique, which is frequently preferred as a hydrophobic coating technique, is used. In this technique, there is a material holding apparatus that goes up and down in a certain cycle, and there

is a mixing container on the bottom where the solution can be placed. It includes the method of providing coating by immersing the material to be coated in the mixture solution prepared in the cycle entered through the device [9-19].

Aerogel products, which have been popular in recent years, are used in water repellent applications due to their super hydrophobic structure. When the literature studies in this area are examined, aerogel-based studies have been carried out on different coating technologies and it has been revealed in the studies that it has water repellent potential [8-19].

Aerogel material is the solid state of the liquid component in a gel that has been replaced by air. Aerogel material; It is used in many areas such as thermal insulation, acoustic insulation, space and aviation applications, catalyst and catalyst fillings, fuel cells, chemical sensors, drug release systems, window applications. The aerogel, which scientists call "frozen smoke", is not affected by the explosion of 1 kilogram of dynamite, together with its bulletproofness, and can protect from temperatures up to 1300 ºC and cold down to -120 ºC [20,21].

Silica material is used as another water-repellent material such as aerogel. Silica is a silicon oxide with the chemical formula SiO_2, found in nature most commonly as quartz and in various living organisms. In many parts of the world, silica is the main component of sand. When the literature research was examined, silica-based hydrophobic surface coatings were studied. When the water repulsion potentials were investigated, while the repulsion property was found for a certain time, the water repulsion potentials decreased during the increasing time. Thus, the search for new materials and the need for blend materials have increased. Since aerogel products also have compatibility problems, interface compatibility between the surface to be coated is ensured by creating a mixture with new materials on the coating surfaces [12,13].

Electrospinning technique is the production of nanofiber membranes from polymer solutions with the help of electric field. It is a system that allows simple, low-cost and functional material production. The nanofiber structure is defined as one-thousandth of a human hair strand [14-16].

In this study, composite mixed materials were coated on glass and nanofiber membrane surfaces by dip coating technique, on the basis of improving the individual properties of both aerogel and silica coating agents in water repellent properties and coating properties between materials. Thus, super hydrophobic smart surface coating products with high water repellent potential will be obtained.

2. Material and Method

2.1. Material

Aerogel and silica materials were obtained from local companies around us. Pure water, dimethylformamide (DMF), chloroform and polycaprolactone (PCL) with a molecular weight of 80,000 g/mol, Sigma/Aldrich brand were used. In the electrospinning technique, oiled paper was preferred as the substrate.

2.2. Method

***Super Hydrophobic Water Repellent Smart Surface Coating Production**

Before the electrospinning technique, 10 grams of PCL in a solvent system with a 60/40 chloroform/DMF mixture is heated up to 55 ºC in a mixture for 60 minutes and dissolved in a magnetic stirrer, and fed 3 milliliters per hour on oiled paper at room conditions by electrospinning technique. A nanofiber membrane was obtained with a speed of 30 kV and a distance of 20 cm between the syringe and the collector.

In order to homogeneously coat the aerogel and silica materials, it was first frozen with the help of liquid nitrogen in a ball mill and then crushed to 100 micrometer size. The obtained powders were blended to be 50-50% and the mixture was provided in dry form, and a homogeneous mixture was obtained by putting them into 100 ml of pure water. This mixture solution obtained was dried in a vacuum oven at room temperature by providing a homogeneous coating by dipping and removing in a certain cycle in the dip coating technique. Production steps of super hydrophobic water repellent smart surface coating are given in Figure 2.1.

The products produced as a result of the electrospraying process are taken into centrifuge tubes and stored at 5,000 rpm for 30 minutes. time centrifuged. At the end of the process, half of the centrifuge tube was emptied into a container, pure water was added and centrifuged at 5,000 rpm for 30 minutes. This procedure was applied three times. After the last process, half of the tubes were discharged into a container, the caps of the centrifuge tubes were removed and closed with parafilm, and small holes were opened on the parafilm. After the procedure, it was kept in a refrigerator at -80 ºC for two days. After the waiting period, it was taken to the lyophilizer device and the drying process was carried out. Micro/nano particles were obtained as a result of the lyophilizer process. The polymer/crosslinker ratio was set to 6/1. Thus, it was desired to produce monodisperse particles of equal size. Micro/Nanoparticles were stored at -18 °C until use [17-27]. In Figure 2.1., the micro/nanoparticle production stages of our SA-X-700 patented product are shown.

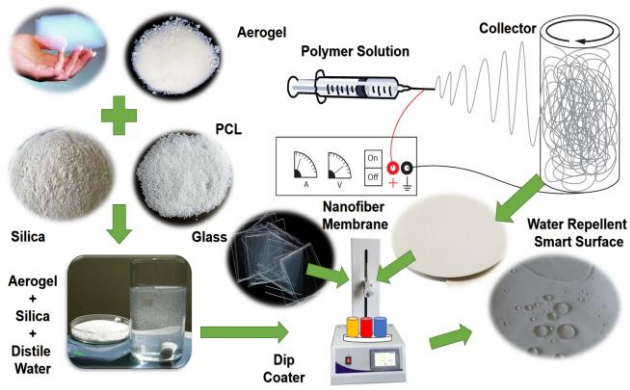

Figure 2.1. *Production steps of super hydrophobic water repellent smart surface coating*

3. Result and Discussion

A mixture of aerogel and silica was homogeneously coated on the nanofiber membrane and glass surface obtained by electrospinning technique by dip coating technique. The morphological images of the obtained nanofiber membrane were taken with scanning electron microscopy (SEM). Figure 3.1. shows the nanofiber membrane and SEM image. The nanofiber diameter distribution obtained is in the range of 180-380 nm.

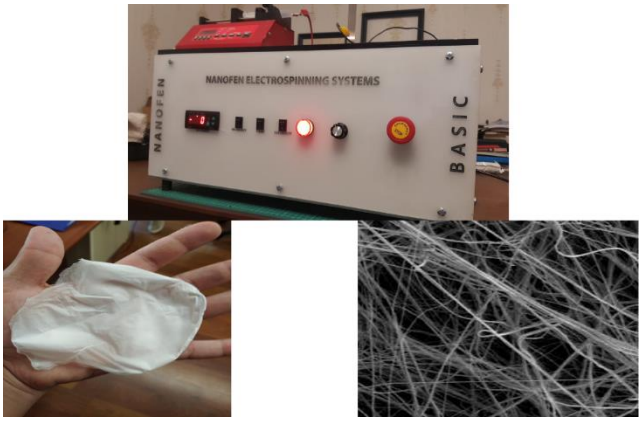

Figure 3.1. Nanofiber membrane and SEM image

4. Conclusion

In this study, homogeneous coating was achieved on glass and electrospun nanofiber membrane by dip coating technique with products containing a mixture of aerogel and silica successfully. It was observed that the mixture coated on the obtained glass and nanofiber membrane surfaces repels water perfectly. Considering the functional use of the products produced, they can be ideal materials that can be used for purpose in many sectors in the industrial field with their water repellent, thermal insulation and durability properties.

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